LAPOX®

Atul

COMPOSITES

EPOXY RESINS, CURING AGENTS AND REACTIVE DILUENTS

Energising possibilities...
Stimulating growth...

LEGACY

Founded in 1947 by a legendary Indian, Kasturbhai Lalbhai, Atul Ltd (Atul), is amongst the first companies of independent India. It has the distinction of being the first private sector company of India to be inaugurated by the first Prime Minister of the country, Pandit Jawaharlal Nehru. It is part of the Lalbhai Group, one of the oldest diversified business houses of the country engaged in manufacturing since 1896. Ever since its inception, Atul has been committed to serving society, particularly in the areas of education, empowerment, health, relief, infrastructure and conservation.

PROFILE

The first site of Atul, spread over 1,250 acres of land, houses one of the largest and the greenest chemical complexes of its kind in the world. Starting with just a few textile dyes, the Company now manufactures 900 products and 450 formulations, managing complex chemical processes in a responsible way. It has also established fruitful and time-tested collaborations with leading multinational companies of the world.

Atul serves customers belonging to diverse industries including Adhesives, Agriculture, Animal Feed, Automobile, Composites, Construction, Cosmetic, Defence, Dyestuff, Electrical and Electronics, Flavour, Food, Footwear, Fragrance, Glass, Home Care, Horticulture, Hospitality, Paint and Coatings, Paper, Personal Care, Pharmaceutical, Plastic, Polymer, Rubber, Soap and Detergent, Sports and Leisure, Textile, Tyre and Wind Energy. In order to enhance customer focus, the Company has divided its product portfolio into seven businesses - Aromatics, Bulk Chemicals and Intermediates, Colors, Crop Protection, Floras, Pharmaceuticals and Intermediates and Polymers, and has established subsidiary companies in the USA, the UK, China, Brazil and the UAE.

PURPOSE

We are committed to significantly enhancing value for our Stakeholders by:

- fostering a spirit of continuous learning and innovation
- adopting developments in science and technology
- providing high quality products and services, thus becoming the most preferred partner
- having people who practice values and exemplify a high standard of behaviour
- seeking sustained, dynamic growth and securing long-term success
- taking responsible care of the surrounding environment
- improving the quality of life of the communities we operate in

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POLYMERS BUSINESS

Epoxy resins, reactive diluents and curing agents are manufactured and marketed under the trade name 'Lapox®' by the Polymers Business of Atul. The manufacture of epoxy systems began in 1960 in Cibatul Ltd, a joint venture between the erstwhile Ciba-Geigy (Switzerland) and Atul. Following the disintegration of Ciba-Geigy, Cibatul was merged into Atul in 1999.

The state-of-the-art manufacturing facilities for these products are located in Atul complex, 200 km north of Mumbai. In addition to its leadership position within India, Polymers also sells to discerning customers outside the country. The Business has been awarded ISO 9001:2008 and ISO 14001.

Epoxy product range

Resins

Bisphenol-A and Bisphenol-F based resins
Cycloaliphatic resins
Epoxy phenol novolac resins
Modified and formulated resins
Multifunctional resins

Reactive diluents

Aliphatic and Aromatic (mono, di and trifunctional)

Curing agents

Aliphatic amines and their adducts
Aromatic amines and their adducts
Cycloaliphatic amines and their adducts
Phenalkamines
Polyamides and Polyamidoamines

Accelerators and catalysts

Tertiary amines

Industries served

Adhesives
Aerospace and Defence
Automotive
Composites
Construction
Electrical and Electronics
Food and Beverage packaging
Marine
Paint and Coatings
Sports and Leisure
Transport
Wind Energy

Lapox® range of products for composites

Atul's epoxy systems are designed to achieve high performance in the composites industry for various process techniques including:

Compression moulding
Contact moulding
Filament winding
Hand lay-up
Prepregging
Pultrusion
Resin Infusion (RI)
Resin Transfer Moulding (RTM)

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FILAMENT WINDING AND PULTRUSION SYSTEMS

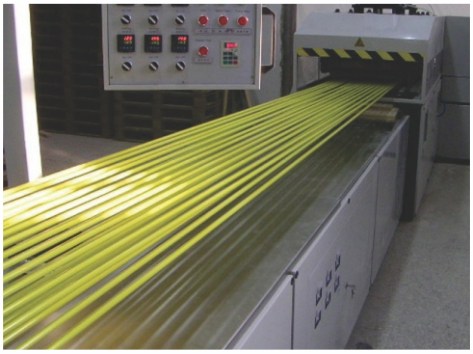
Atul offers several epoxy systems for filament winding and pultrusion applications. Suitable epoxy systems may be selected as per the process and performance requirements. These systems may be processed with a variety of reinforcements at ambient and elevated temperatures. Components manufactured with epoxy systems offer excellent mechanical, electrical, chemical, thermal and physical properties for various filament winding and pultrusion applications.

Ambient cure systems

Lapox® systems	Mixing ratio	Mix viscosity[1] @ 25°C	Pot life[2] @ 25°C	Tg[3]	Recommendations
	Parts by weight	mPa s	minutes	°C	
ARL-12 / AH-714	100 : 50	1,200 - 1,500	120 - 150	55 - 65	Offers superior adhesion with toughness. Good for high pressure vessels.
ARL-135 LV / AH-335	100 : 32	300 - 700	50 - 60	75 - 85	Low viscosity resin system with curing agents offering variable pot life.
ARL-135 LV / AH-336	100 : 32	300 - 700	80 - 100	75 - 85	
ARL-135 LV / AH-337	100 : 32	200 - 300	300 - 380	75 - 85	
ARL-138 / AH-417	100 : 30	200 - 300	90 - 120	100 - 110	Offers high Tg. Enables higher productivity due to its low initial mix viscosity. Facilitates superior wetting of fiber.
L-12 / AH-315	100 : 32	500 - 800	7 - 9 hr	85 - 95	Low viscosity and long pot life system for the manufacture of large components.
L-12 / AH-335	100 : 32	600 - 1,200	50 - 60	90 - 105	Higher Tg can be obtained with a variable pot life.
L-12 / AH-336	100 : 32	600 - 1,200	80 - 100	90 - 105	
L-12 / AH-337	100 : 32	400 - 700	300 - 380	90 - 105	
L-12 / AH-411	100 : 22	800 - 1,200	90 - 120	140 - 155	Recommended for very high Tg and moderate viscosity.
L-12 / AH-422	100 : 32	1,500 - 2,500	300 - 350	130 - 140	Offers a long pot life with high Tg.

[1]Brookfield viscosity
[2]Pot life of 100 g mix mass
[3]Tg: Glass transition temperature
*Method: Mix viscosity - ASTM D5478; Pot life - ASTM D2471; Tg - ISO 11375-2

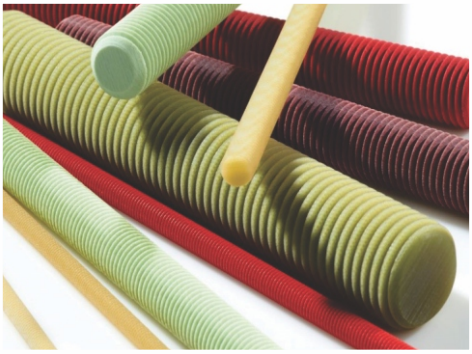


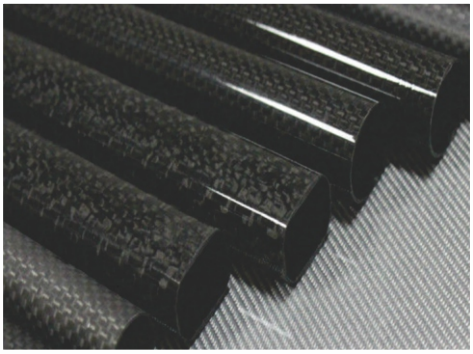


Hot cure systems

Lapox® systems	Mixing ratio	Mix viscosity[1] @ 25°C	Pot life[2] @ 25°C	Tg[3]	Recommendations
	Parts by weight	mPa s	hours	°C	
ARCH-11 / K-3 / K-13	100 : 85 : 1-3	200 - 500	> 8	105 - 115	Cycloaliphatic resin and curing agent recommended for outdoor applications and UV resistance.
ARF-11 / K-918 / K-13	100 : 90 : 1-3	300 - 500	> 8	115 - 130	Non-crystallisable, low viscosity resin with excellent chemical resistance.
ARL-136 / AH-126	100 : 90	300 - 600	> 8	115 - 125	Offers a higher production rate due to its superior fiber wetting property. Optimum curing of this system delivers excellent mechanical and electrical properties with good surface finish.
L-12 / AH-113 / K-13	100 : 95 : 0.5-2.0	1,900 - 2,100	> 8	165 - 185	Laminates made using this system can be subjected to continuous operations at 170°C.
L-12 / AH-667	100 : 27	3,000 - 5,000 @ 50°C	> 8	150 - 160	Recommended for high chemical and abrasion resistance.
L-12 / K-12 / K-13	100 : 100 : 1-3	400 - 700	> 8	95 - 105	Standard system with fast reactivity.
L-12 / K-24	100 : 34	3,500 - 5,000	> 8	145 - 155	Recommended for high chemical and abrasion resistance with low viscosity and a long pot life.
L-12 / K-918 / K-13	100 : 85 : 1-3	600 - 900	> 8	130 - 140	Recommended for general purpose applications.
L-12 / K-5200	100 : 24	4,000 - 6,000	2 - 3 days	180 - 190	Offers very high Tg with a long pot life.
L-247 / K-918 / K-13	100 : 64 : 1-3	–	> 8	110 - 120	General purpose system providing fire retardant properties.

[1]Brookfield viscosity
[2]Pot life of 100 g mix mass
[3]Tg: Glass transition temperature
*Method: Mix viscosity - ASTM D5478; Pot life - ASTM D2471; Tg - ISO 11375-2





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PREPREGS AND LAMINATION SYSTEMS

Atul offers a wide range of resin systems for the manufacture of B-stage prepregs and laminates which meet process and performance requirements. These lamination systems offer excellent impregnation and compatibility with a variety of reinforcements, excellent mechanical strength, high thermal resistance and a varying shelf life of prepregs.

Compressed laminate systems (for electrical and general engineering)

Lapox® systems	Mixing ratio	Pot life[1] @ 25°C	Tg[2]	Recommendations
	Parts by weight	hours	°C	
ARPN-36 / K-10 / K-86	100 : 32-40 : 1-3	> 8	170 - 185	Delivers stable B-stage prepregs with a very high Tg. Recommended for MICA paper impregnation.
ARPN-36 / K-86	100 : 3-6	> 8	165 - 180	Recommended for MICA paper impregnation.
L-12 / K-5	100 : 27	> 4	150 - 160	Recommended for prepregs with a shorter shelf life for G-10 and G-11 laminates.
L-12 / K-10 / K-86	100 : 35 : 1-3	6 - 8 weeks	150 - 160	This system delivers stable prepregs after B-staging with a shelf life of up to 6 months. Recommended for G-11 laminates.
L-67 / K-66 / K-13	100 : 23 : 0.5-3.0	2 - 3 weeks	130 - 140	Recommended for the manufacture of B-stage prepregs and G-10 laminates.
L-68 / K-66 / K-13	100 : 32 : 1-3	2 - 3 weeks	130 - 140	Recommended for the manufacture of B-stage prepregs and FR-4 laminates.
Prepreg systems				
ARL-159 / AH-357 / AC-22	100 : 15 : 2	> 8	155 - 165	Hot melt prepreg system for 150°C Tg. This system may also be used while adding a solvent.
ARL-159 / AH-619	100 : 40	> 8	180 - 200	Structural components for high temperature performance for aerospace, defence and engineering applications.
ARL-160 / AH-357 / AC-22	100 : 15 : 1-3	> 8	110 - 120	Hot melt prepreg system for structural components for sporting goods, defence, aerospace, infrastructure and general engineering applications.
ARL-160 / AH-359	100 : 5	> 8	110 - 120	Recommended for FRP structural components including sporting goods, automobiles, marine equipment and light gliders.

[1]Pot life of 100 g mix mass
[2]Tg: Glass transition temperature
*Method: Pot life - ASTM D2471; Tg - ISO 11375-2



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RTM, HAND LAY-UP AND INFUSION SYSTEMS

Atul offers an extensive product range of epoxy resin systems with variable pot life, cure time, glass transition temperature (Tg) and physical properties. These systems are suitable for various processes including Resin Transfer Moulding (RTM) and Resin Infusion (RI). The variable pot life of these resin systems make them ideal for manufacturing small to very large components, including wind turbine blades. Our range includes GL approved epoxy systems for composite applications.

Lapox® systems	Mixing ratio	Mix viscosity[1] @ 25°C	Pot life[2] @ 25°C	Tg[3]	Recommendations
	Parts by weight	mPa s	minutes	°C	
ARL-125 / AH-365 GL	100 : 32	200 - 300	50 - 60	75 - 85	Low viscosity systems recommended for Resin Infusion, Resin Transfer Moulding, pultrusion, filament winding, hand lay-up lamination, vacuum and pressure bag techniques.
ARL-125 / AH-367 GL	100 : 32	300 - 700	300 - 380	75 - 85	
ARL-135 / AH-332	100 : 32	700 - 1,200	8 - 14	80 - 90	Moderate viscosity systems recommended for Resin Transfer Moulding and hand lay-up for small to large components.
ARL-135 / AH-333	100 : 32	700 - 1,200	14 - 20	80 - 90	
ARL-135 / AH-334 GL	100 : 32	700 - 1,200	25 - 35	80 - 90	
ARL-135 / AH-335	100 : 32	500 - 700	50 - 60	75 - 85	
ARL-135 / AH-336	100 : 32	500 - 700	80 - 100	75 - 85	
ARL-135 / AH-337	100 : 32	300 - 500	300 - 380	75 - 85	
ARL-135 LV / AH-332	100 : 32	600 - 800	8 - 14	75 - 85	Low viscosity systems with variable pot life. Recommended for Resin Transfer Moulding and Resin Infusion processes for small to large components, including wind turbine blades.
ARL-135 LV / AH-333	100 : 32	600 - 750	14 - 20	75 - 85	
ARL-135 LV / AH-334	100 : 32	600 - 750	25 - 35	75 - 85	
ARL-135 LV / AH-335	100 : 32	300 - 700	50 - 60	75 - 85	
ARL-135 LV / AH-336	100 : 32	300 - 700	80 - 100	75 - 85	
ARL-135 LV / AH-337	100 : 32	200 - 300	300 - 380	75 - 85	
ARL-135 LV / AH-411	100 : 24	250 - 400	90 - 120	125 - 135	Very low viscosity system with a high Tg. Recommended for Resin Infusion and hand lay-up.
ARL-135 LV / AH-422	100 : 35	400 - 600	300 - 350	110 - 120	Fully cured components made using this system offer a long pot life and high Tg. Recommended for hand lay-up and Resin Infusion of large components.
ARL-143 / AH-319	100 : 15	3,500 - 5,000	20 - 25	95 - 105	Moderate viscosity modified epoxy resin and two curing agents with varying pot life to suit different processing techniques. Recommended for fire retardant applications.
ARL-143 / AH-335	100 : 15	3,500 - 5,000	85 - 95	95 - 105	
L-552 / K-552	100 : 38	600 - 700	110 - 160	115 - 130	Low viscosity system with a high Tg.

[1]Brookfield viscosity
[2]Pot life of 100 g mix mass
[3]Tg: Glass transition temperature
*Method: Mix viscosity - ASTM D5478; Pot life - ASTM D2471; Tg - ISO 11375-2

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TOOLING SYSTEMS

Atul offers various gel coats and laminating systems for manufacturing prototypes and moulds. Laminating systems are available with variable pot life and viscosity to manufacture small to large moulds. The variable pot life of these epoxy systems make them suitable for hand lay-up and Resin Infusion processes.

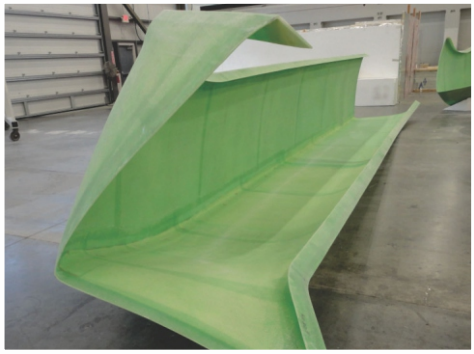
Gel coat systems

Lapox® systems	Mixing ratio	Mix viscosity[1] @ 25°C	Pot life[2] @ 25°C	Tg[3]	Recommendations
	Parts by weight	mPa s	minutes	°C	
ART-21 / AH-326	100 : 14	Paste (white)	25 - 30	75 - 85	General purpose gel coat for all types of moulds.
ART-22 / AH-326	100 : 6	Paste (grey)	15 - 20	85 - 95	Gel coat with high thermal conductivity, excellent hardness and surface finish.
ART-23 / AH-326	100 : 10	Paste (blue)	15 - 20	75 - 85	Gel coat with exceptionally high hardness and abrasion resistance coupled with a good finish.
ART-24 / AH-326	100 : 20	Paste (colourless)	15 - 20	95 - 115	Colourless gel coat which can be suitably tinted.

Laminating systems

ARL-135 LV / AH-411	100 : 24	250 - 400	90 - 120	125 - 130	Very low viscosity system with high Tg. Recommended for Resin Infusion and hand lay-up.
ARL-138 / AH-339	100 : 30	400 - 600	120 - 180	130 - 140	Standard tooling system with excellent Tg. Suitable to make tools with hand lay-up and infusion processes of varying sizes.
ARL-138 / AH-417	100 : 30	200 - 300	90 - 120	100 - 110	Suitable to make tools with hand lay-up and infusion processes of varying sizes.
ARL-140 / AH-419	100 : 42	2,500 - 3,000	600 - 700	190 - 220	Offers high Tg for dimensional stability even at high temperatures.
L-552 / K-552	100 : 38	600 - 700	110 - 160	115 - 130	Low viscosity system with a high Tg.

[1]Brookfield viscosity
[2]Pot life of 100 g mix mass
[3]Tg: Glass transition temperature
*Method: Mix viscosity - ASTM D5478; Pot life - ASTM D2471; Tg - ISO 11375-2

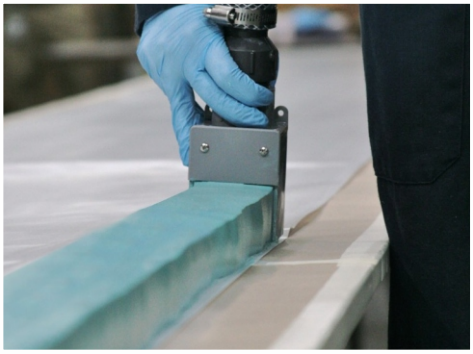



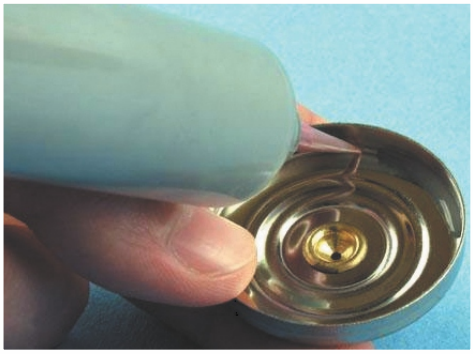

ADHESIVE SYSTEMS

The range of adhesives offered by Atul are suitable for joining similar and dissimilar substrates for high performance applications using different processes.

Lapox® systems	Mixing ratio	Mix viscosity[1] @ 25°C	Pot life[2] @ 25°C	Recommendations
	Parts by weight	mPa s	minutes	
A-16 / AH-800	100 : 100	Thixotropic	3 - 7	Rapid cure adhesive suitable to bond similar or dissimilar substrates which cures within 7 minutes.
A-31 / AH-717	100 : 80	25,000 - 40,000	130 - 150	Standard adhesive for glass, metal, FRP and wood.
A-83 / K-83	100 : 40	Thixotropic	35 - 45	Standard adhesive with thixotropic properties to fill gaps up to 5 mm.
ARA-17 / AH-354	100 : 80	75,000 - 1,25,000	8 - 10	Provides excellent toughness with quick mechanical strength.
ARA-30 / AH-735	100 : 50	50,000 - 1,00,000	35 - 50	Thixotropic structural adhesive with high lap shear strength.
XR-110 / XH-68	100 : 100	3,000 - 4,000	25 - 35	Special adhesive used for flexible cable joints.

[1]Brookfield viscosity
[2]Pot life of 100 g mix mass
*Method: Mix viscosity - ASTM D5478; Pot life - ASTM D2471





GLOSSARY

B-stage
B-stage is an intermediate reaction stage of thermosetting resins. A material in this stage softens when heated and swells when it comes in contact with certain solvents. However, it does not fuse or completely dissolve.

Cross-linking
Reactive sites of the resin and curing agent make chemical bonds and form a three-dimensional network. Cross-linking starts as soon as the resin and curing agent come into physical contact. The speed of the reaction (i.e. of cross-linking) depends on the type of resin, curing agent and the temperature.

Cure time
Cure time is the amount of time required for a liquid resin-curing agent mix to convert into a completely cross-linked solid mass. It depends on various factors including the type of resin, curing agent and the temperature.

Elastic modulus
Every object deforms elastically when force is applied. This deformation is completely reversed when the applied force is removed. Elastic modulus is a measure of stiffness of the material or object.

Elongation
Elongation is defined as the change in length of a specimen or object when load is applied under tension, bending or any other mode.

Epoxide Equivalent Weight (EEW)
EEW is the weight of the resin in grams that contains one gram-equivalent of epoxy. An interchangeable term, Epoxy Value (EV) may also be used. EV represents the fractional number of epoxy groups contained by 1,000 grams of resin. EEW can be obtained if 1,000 is divided by EV.

Gel time
Gel time is the amount of time required for a resin-curing agent mix to convert into a jelly-like mass. It depends on the type of resin and curing agent, the quantity of the mix and the temperature.

Glass Transition Temperature (Tg)
This is the critical temperature at which the polymer transitions from a hard, glassy material to a soft, rubbery material.

Post curing
When resin and curing agent react, cross-linking takes place and a solid, cured mass is obtained. In certain epoxy systems, even though the material appears cured and hard, optimum mechanical properties are not achieved. This happens due to the presence of free reactive sites of the resin and curing agent that can be completely cross-linked by heating (post curing) at appropriate temperatures.

Pot life
The amount of time taken to retain processable (i.e. usable) viscosity of a resin-curing agent mix. Mix viscosity increases with time. Pot life is dependent on the type of resin and curing agent, quantity of mix and the temperature.

Shrinkage
Shrinkage is defined as the change in dimension that occurs in a polymer(s) when cross-linking takes place. Volume shrinkage is expressed as a percentage while linear shrinkage is measured in millimeters or inches.

Stiffness
This is the measure of resistance to deform when under stress by an object. A material with high stiffness is brittle and displays high modulus.

Toughness
Toughness is a material's resistance to fracture when under stress. It is measured as the amount of energy absorbed by unit volume of material before disintegration.

Viscosity
The internal resistance of a liquid to flow, viscosity can also be defined as 'fluid friction'.

MAJOR RESINS, CURING AGENTS AND THEIR SPECIAL FEATURES

Types of resins	Special features
Bisphenol-A based resins	General purpose basic resin in liquid and solid forms to achieve a combination of physical, electrical, mechanical, thermal and electrical properties
Bisphenol-F based resins	Relatively low viscosity, high chemical resistance and low crystallisation at lower temperatures
Brominated epoxy resins	Available in semi-solid and solid forms; used for flame retardancy
Carboxyl-terminated butadiene-acrylonitrile (CTBN) rubber modified resins	Higher viscosity, fracture toughness and impact resistance
Cycloaliphatic epoxy resins	Low viscosity and UV resistance
Epoxy acrylates	Quick curing by UV light for faster production
Fatty acid modified resins	High flexibility, low shrinkage and good adhesion properties
Phenol and cresol novolac epoxy resins	Relatively high viscosity, reactivity, thermal stability and chemical resistance
Polyurethane modified resins	High flexibility, low shrinkage and excellent adhesion properties
Reactive diluent modified resins	Low viscosity, high elongation and easy processibility
Silicone modified resins	High heat and thermal shock resistance
Tetrafunctional epoxy resins	High heat resistance, glass transition temperature and stiffness
Types of curing agents	**Special features**
Aliphatic and cycloaliphatic amine curing agents and adducts	Enables fast curing in the presence of accelerators
Anhydrides	Available in liquid and solid forms with elevated temperature curing and high electrical resistant properties
Aromatic amines	Available in liquid and solid forms with slow reactivity, elevated temperature curing and high performance properties
Mercaptans	Ambient curing, quick setting, high elongation
Phenalkamines	Low temperature curing, sea (saline) water resistant with good film forming character
Phenolics	Available in liquid and solid forms with elevated temperature curing, high heat and chemical resistant properties
Polyamides	Ambient curing, good adhesion and high flexibility

KEY MARKETS

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Jan 2017

POLYMERS | AROMATICS | BULK CHEMICALS AND INTERMEDIATES | COLORS | CROP PROTECTION | FLORAS | PHARMACEUTICALS AND INTERMEDIATES

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